FIELD EXPERIENCES

Amy Epps Martin	Texas A&M
Dale Rand	TxDOT
Dean Weitzel, Darren Tedford	NDOT
Peter Sebaaly	UNR
Lerose Lane, Terrie Bressette	Caltrans
G. W. Maupin, Jr.	VDOT

February 4, 2003

Field Experiences

- Field Performance = Ultimate Test

- CA
- NV
- TX
- VA

- History
- Solutions
- Tools
- Specifications

California Experience

Terrie Bressette
Office of Flexible Pavement Materials

Lerose Lane
District Materials Engineer – District 2 (Redding)

1960 thru 1990's 1999 2001 2004

Problem Identification

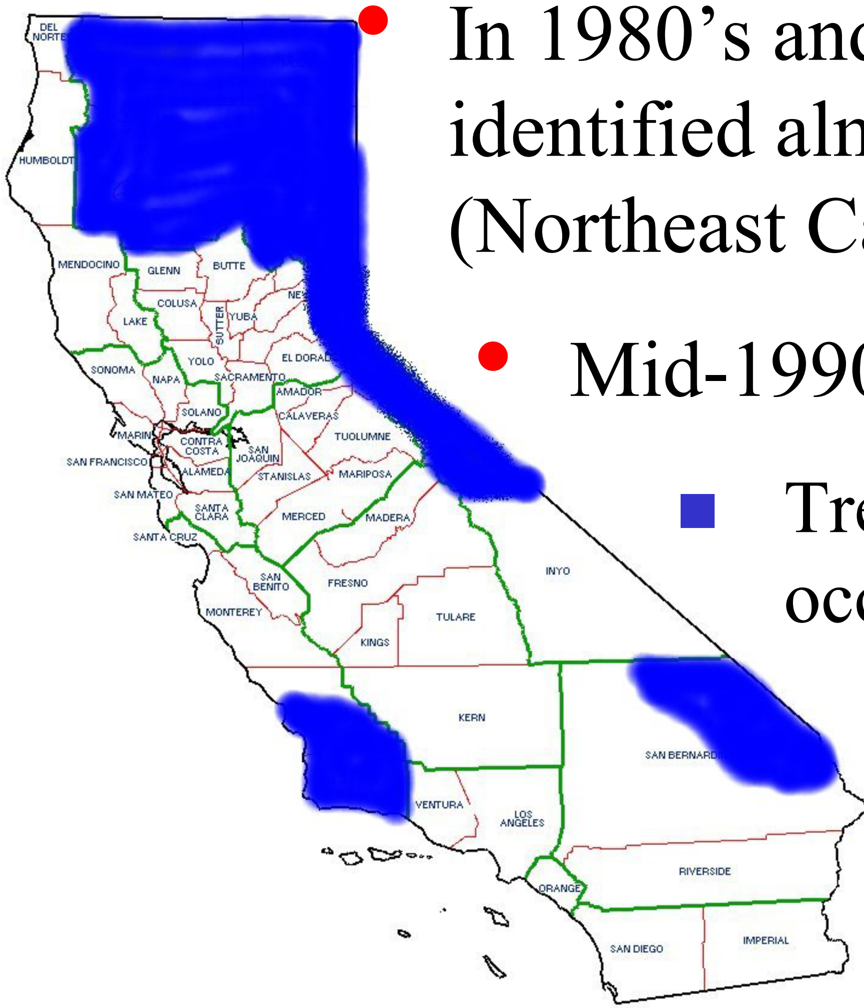
Interim Guidelines

Partnering

Testing & Treatment Matrix

Implementation

Historical Perspective



- In 1980’s and early 1990’s stripping identified almost exclusively in District 2 (Northeast California)
  - Mid-1990’s Lime Slurry Marination:
    - Treatment of choice with occasional use of liquid anti-strip
      - Appearing in projects in D2, Sierra’s and East of Sierra’s, High Desert, Mid-Coastal

Historical Perspective

- Mid-1990’s Contractors Contest Testing
- Late-1990’s Partnering Fails to Resolve Issues
- 1998 Caltrans Institutes “Interim Guidelines”
- 2001 Formalized Partnering effort
- 2002-04 Development and Implementation of “Testing & Treatment Matrix”

Interim Guidelines

(1999 – Present)

- No Problem ➡ No Treatment
- Past Treatment ➡ Same Treatment
- Identified Problem ➡ Lime Slurry
- New Aggregate Source ➡ Case-by-Case

Interim Guidelines - Issues

- Subjective Approach
- Not Uniformly Applied
- Lime “Creep”
- Limited Treatment Choices
- Increased Project Costs

Historical Perspective

- Mid-1990's Contractors Contest Testing
- Late-1990's Partnering Fails to Resolve Issues
- 1998 Caltrans Institutes "Interim Guidelines"

- 2001 Formalized Partnering effort
- 2002-04 Development and Implementation of "Testing & Treatment Matrix"

Mutual Issues

- Problem Identification
  - ✓ Is it materials?
  - ✓ Is it construction?
- Lab Testing
  - ✓ Reliable and repeatable?
  - ✓ Correlated with field performance?
- Treatment
  - ✓ Necessary and effective?
  - ✓ Alternatives?

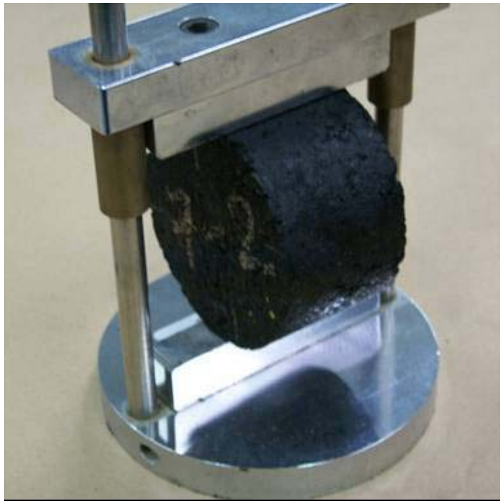
Caltrans – Industry Partnering

- Moisture Sensitivity Asphalt Concrete Task Group (MSACTG)
- Goal – Resolve Issue
  - ✓ Problem Identification
  - ✓ Testing & Treatment
  - ✓ Implementation

MSACTG Strategy

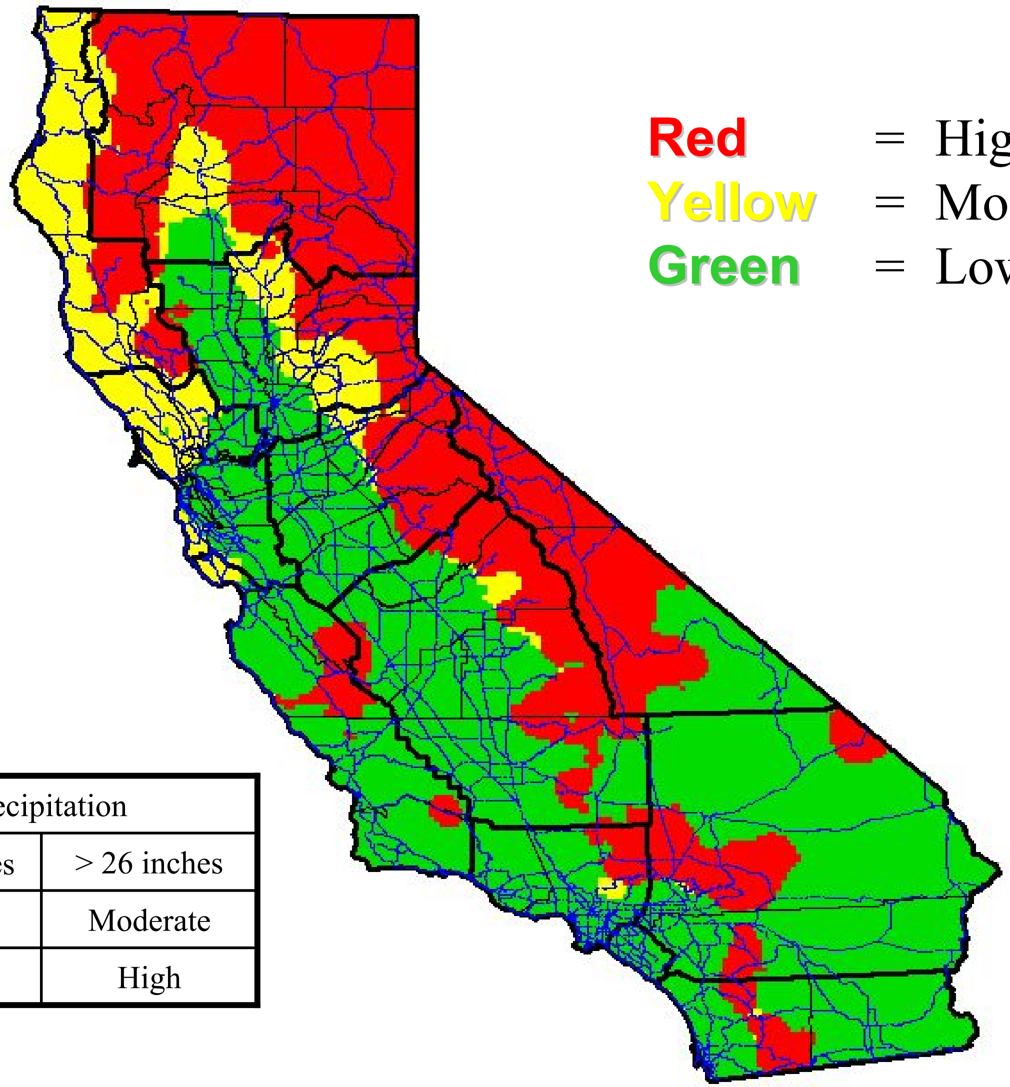
- Long-Term Goal
  - ✓ Correctly Identify Problem
  - ✓ Lab Test that Predicts Field Performance
  - ✓ Consider other treatment alternatives
  - ✓ Education and Technology Transfer

MSACTG Strategy



- Short-Term Goal
  - ✓ Testing & Treatment Matrix
    - Environmental Risk
    - Traffic
    - Mix Risk by CT 371 (Modified AASHTO T283)
    - Treatment alternatives

Environmental Risk



Red = High
Yellow = Moderate
Green = Low

Freeze/Thaw	Precipitation	
	≤ 26 inches	> 26 inches
≤ 50 cycles	Low	Moderate
>50 cycles	High	High

Testing & Treatment Matrix

(*Low* Environmental Risk)

TSR	Mix Risk	Treatment	TSR after Treatment
≥ 70	Low	None Required	
51 - 69	Moderate	LAS, DHL, LSM **	≥ 70
≤ 50	High	DHL, LSM **	

LAS – liquid anti-strip
DHL – dry hydrated lime with no marination
LSM – lime slurry with marination
***** select one treatment***

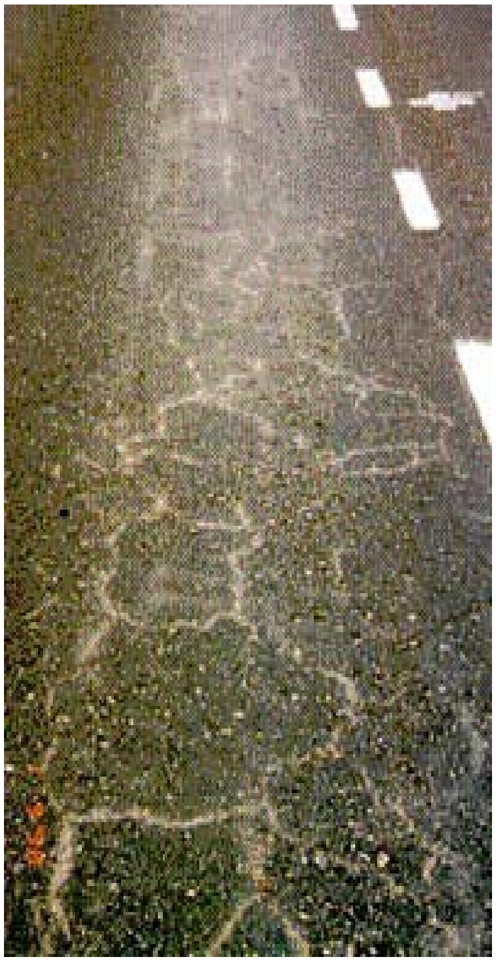
Testing & Treatment Matrix

(*Moderate & High* Environmental Risk)

TSR	Mix Risk	Treatment	TSR after Treatment
≥ 75	Low	None Required	
61 - 74	Moderate	LAS, DHL, LSM **	≥ 75
≤ 60	High	LSM **	≥ 75

LAS – liquid anti-strip
DHL – dry hydrated lime with no marination
LSM – lime slurry with marination
***** select one treatment***

Concerns



- Distress Identification
  - ✓ Materials, Construction or Both?
- CT 371
  - ✓ Indicative of Field Performance?
  - ✓ Repeatable & Reproducible?
- Implementation
  - ✓ Schedule
  - ✓ Costs

1960 thru 1990's 1999 2001 2004

Problem Identification

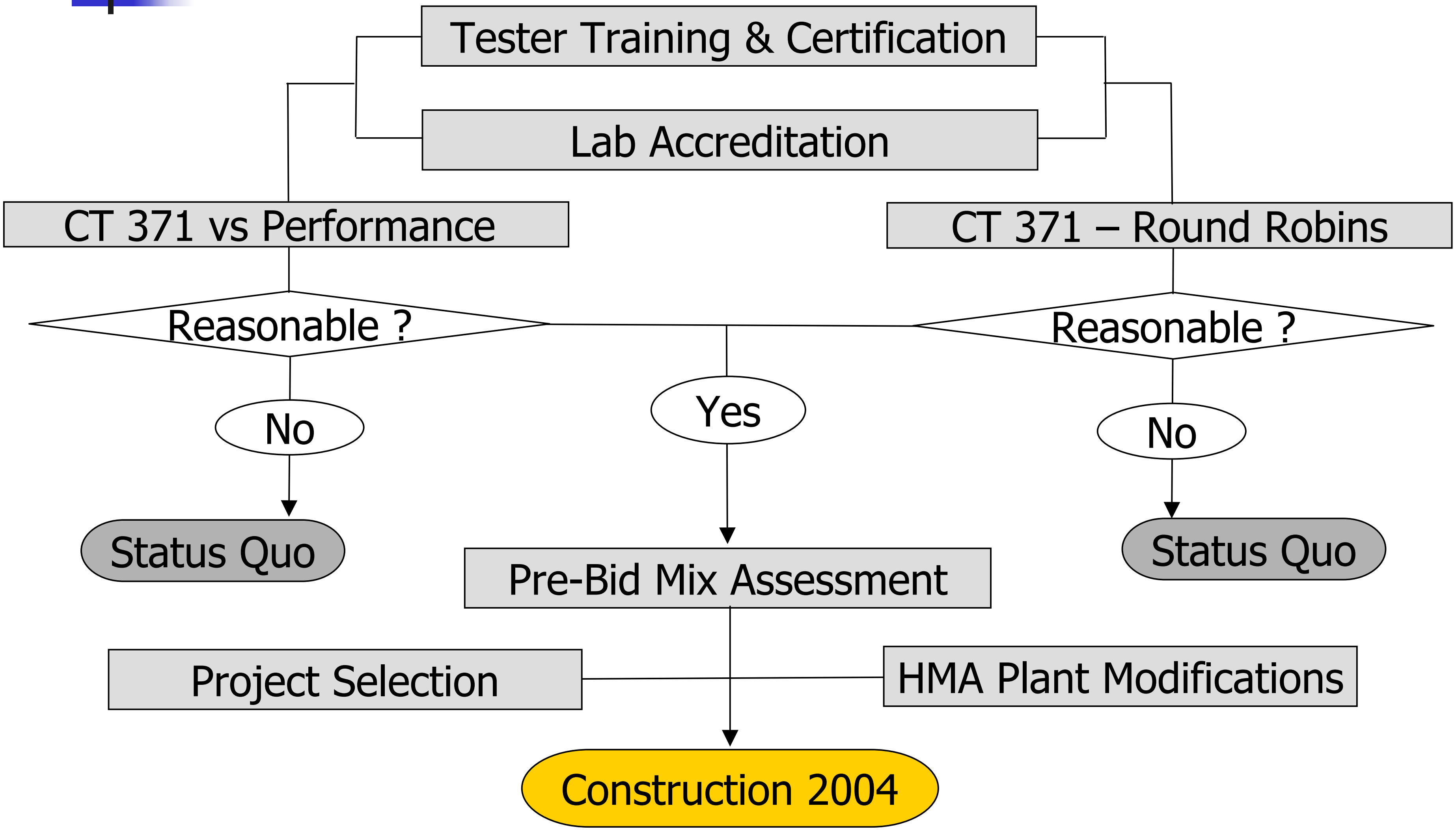
Interim Guidelines

Partnering

Short-Term Strategy

Implementation

Implementation Process



Implementation Constraints

- HMA Plant Modifications
  - ✓ Capitol Costs
  - ✓ Weights & Measures Compliance
- Project Selection
- Budget/Resource
- Time

Implementation Status

- Testers Trained & Certified
  - ✓ 28 Certified
  - ✓ 36 Pending Training
- Labs Accredited
  - ✓ 5 State
  - ✓ 8 Commercial/Contractor
  - ✓ 20 – Under Review
- Round Robin Testing - 13 Labs

NEVADA DOT MOISTURE SENSITIVITY HISTORY

DEAN WEITZEL, NDOT

DARIN TEDFORD, NDOT

Dr PETER SEBAALY, UNR

CALTRANS NATIONAL SEMINAR

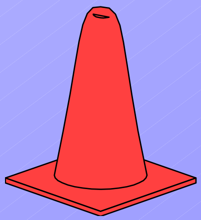
MOISTURE SENSITIVITY

SAN DIEGO, CA 2003

- **1983 DEETH PROJECT**
  - Moisture sensitivity test
  - Test on loose mix
  - Test on compacted mix

- **1986 SPECIFICATION CHANGES**
  - Polymer modified binders experiment
  - Lime in mixture north of US 6
  - Lime in selected projects in south

- **1987 SPECIFICATION CHANGES**
  - PI from 6 to NP
  - If PI>NP add lime
- **1990 SPECIFICATION CHANGE**
  - Mandatory 48hr. Marination for PI
- **1992 SPECIFICATION CHANGES**
  - Lime in mixtures south of US 6



- **1994 SPECIFICATION CHANGES**
  - Lottman specification
  - 65 PSI Min. ITS, 70% Min. TSR
  - NP From 0 to 3
- **1996 $2.8M PI / MARIN. CLAIM**
- **1997 LOTTMAN DATA REVIEW**

- **1998 SPECIFICATION CHANGES**
  - Mandatory marination
  - Max. 10 PI in stockpile
  - 60-day limit on stockpile

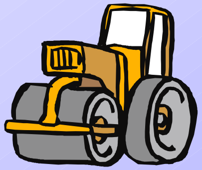
- **2001 SPECIFICATION CHANGES**
  - Shutdown specifications

MOISTURE SENSITIVITY CONTRACT DATA ANALYSIS 1997-1999

Mix Design Data

PROPERTY	Marinated			Non-marinated		
	97	98	99	97	98	99
No. of samples	39	80	70	28	13	7
Uncond. Tensile Strength, PSI	101	87	99	122	121	140
Fail @ 65 psi, %	0	14	0	0	0	0
Strength Ratio, %	84	90	94	81	84	86
Fail @ 70%	13	1.3	1.4	25	15	0

MOISTURE SENSITIVITY CONTRACT DATA ANALYSIS 1997-1999



Behind-the-Paver Results

PROPERTY	Marinated			Non-marinated		
	97	98	99	97	98	99
No. of samples	118	312	370	114	95	61
Uncond. Tensile Strength, PSI	94	88	97	118	143	131
Fail @ 65 psi, %	12	9	1	2	0	0
Strength Ratio, %	89	90	94	76	82	81
Fail @ 70%	3.4	2.2	3.8	30	16	8

TIME MARINATION STUDY 1998

North

Agg. Source	Binder Grade	48 hrs		45 days		60 days		120 days	
		Strength	Ratio	Strength	Ratio	Strength	Ratio	Strength	Ratio
Lockwood	AC-20	107	88	138	40	146	30	139	43
	AC-20P	75	85	101	38	72	46	96	50
	PG64-28	70	74	101	36	93	47	110	61
Dayton	AC-20	115	96	138	62	110	61	109	79
	AC-20P	82	95	85	70	75	63	91	75
	PG64-28	79	93	107	66	88	66	91	65

TIME MARINATION STUDY 1998

South

Agg. Source	Binder Grade	48 hrs		45 days		60 days		120 days	
		Strength	Ratio	Strength	Ratio	Strength	Ratio	Strength	Ratio
Lone Mtn.	AC-20	164	91	142	96	138	100	143	97
	AC-20P	124	103	133	91	120	100	116	96
	PG64-28	100	90	127	63	104	68	92	69
Suzie Creek	AC-20	82	85	88	70	90	76	116	44
	AC-20P	52	133	60	89	67	74	62	66
	PG64-28	62	111	74	96	71	70	87	30

LIME ADDITION METHOD STUDY

- Objective: Most effective method to add lime
- Three aggregate sources
- Three asphalt binders
- Four addition methods:
  - None
  - Lime no marination
  - Lime 48hr marination
  - Lime Slurry method
  - Lime slurry 48hr marination

LIME ADDITION METHOD STUDY

- **Tests:**
  - TS
  - TSR 1 F/T Cycle
  - TSR 18 F/T Cycle

- **Conclusion:**
  - No lime performed worst
  - Lime was effective in all methods
  - 80% of the time gave similar results
  - 20% of the time 48hr was the most effective

IMPACT OF LIME ON PAVEMENT PERFORMANCE

- **Objective: Lime effectiveness field projects**
- **Compare lime treated and non-lime projects**
- **Conclusion:**
  - **Lime treatment extended pavement life**
  - **Average increase of 3 years**
  - **38% life increase**
  - **6% cost increase**

CURRENT SPECIFICATION

- Mandatory marination
- 1% lime on coarse aggregate
- 2% lime on fine aggregate
- 65psi min. dry TS
- 70% min. TSR
- Max. PI : 10
- Min. marination : 48hr
- Max. marination : 60 days
- Shutdown:
  - On 2 consecutive failure
  - Or, 40% failure

MOISTURE SENSITIVITY CONTRACT DATA ANALYSIS 2002

	Mix Design Data (all marinated)	Behind the Paver results
No. of samples	47	206
Uncond. TS, psi	105	109
Fail @ 65 psi	0	0
Strength ratio, %	88	91
Fail @ 70 %	6.4	0

FUTURE ISSUES

- Repeatability / Repeatability of AASHTO T283.
- Relate AASHTO T-283 to performance.
- Long term effectiveness of lime/antistrip.
- Effect of moisture sensitivity on rutting, fatigue, thermal cracking.
- Improve construction methods/equipment.
- Identify improved test methods.

TxDOT Experiences with Moisture Damage in Hot Mix

Texas Department of Transportation

DaleA. Rand, P.E.

TxDOT Construction Division

Background

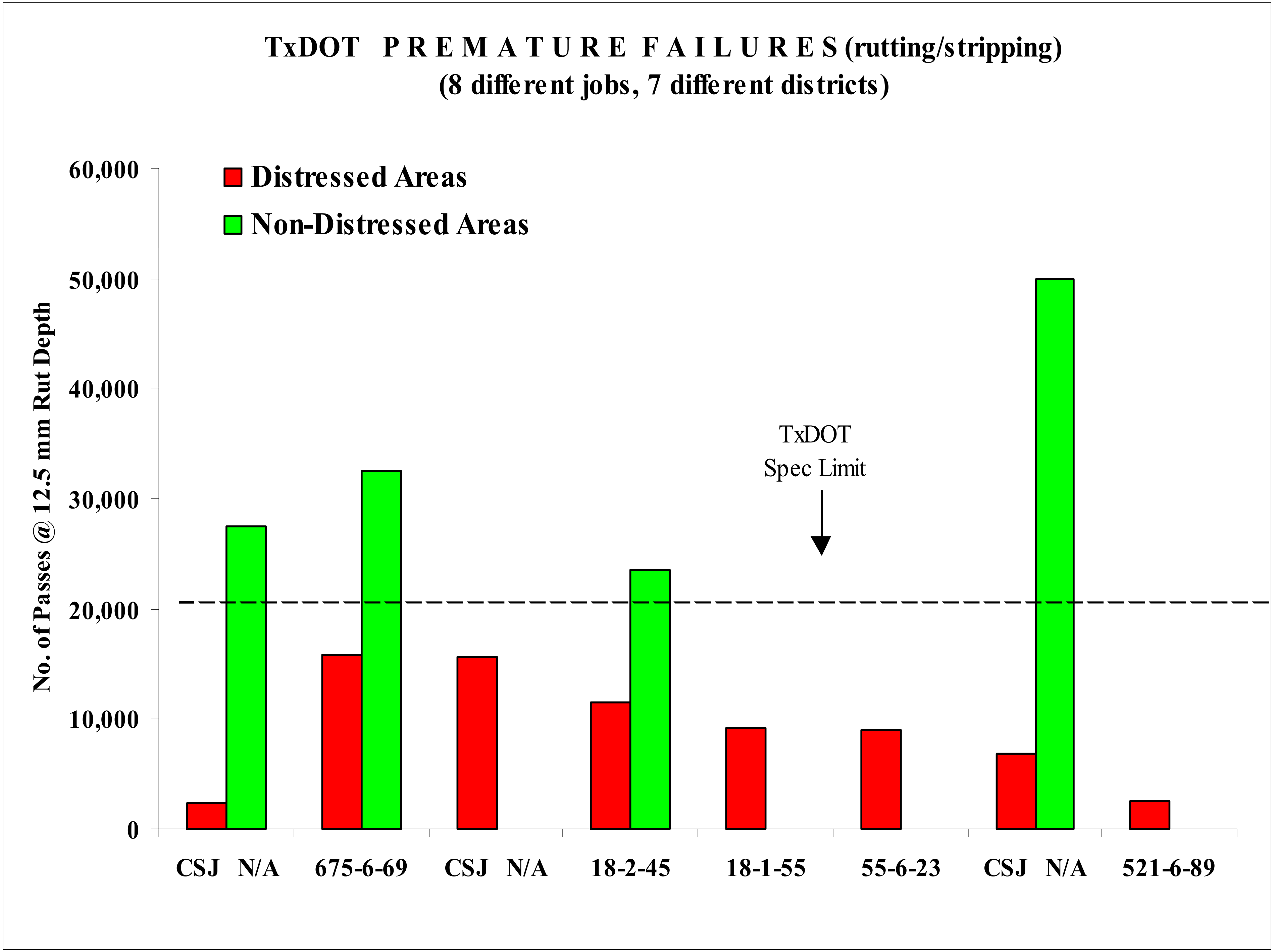
- TxDOT was experiencing approximately 3 premature failures per year related to stripping and/or rutting.
- Conventional tests did not correlate with performance.
- Extensive field studies showed that AASHTO T-283 (Tex-531-C) did a poor job identifying mixtures susceptible to moisture damage.

Future Direction

- Hamburg Wheel Track testing will be required on all mixture designs and during production
- Hamburg criteria based on grade of asphalt
- AASHTO T283 (Tex-531-C) will no longer be used on TxDOT projects

Synopsis of Research Conducted by CTR, TTI and TxDOT on 140 Pavement Sections

- ASHTO (T-283)
  - Not a good indicator of field performance
  - Highly variable (poor reproducibility)
- Hamburg Wheel Track Testing
  - Correlates well with visual performance
  - Indicates benefits of using better paving materials
  - Identifies mixtures susceptible to premature failure


TxDOT PREMATURE FAILURES (rutting/stripping)
(8 different jobs, 7 different districts)
Distressed Areas
Non-Distressed Areas
No. of Passes @ 12.5 mm Rut Depth
60,000
50,000
40,000
30,000
20,000
10,000
0
TxDOT
Spec Limit
CSJ N/A
675-6-69
CSJ N/A
18-2-45
18-1-55
55-6-23
CSJ N/A
521-6-89

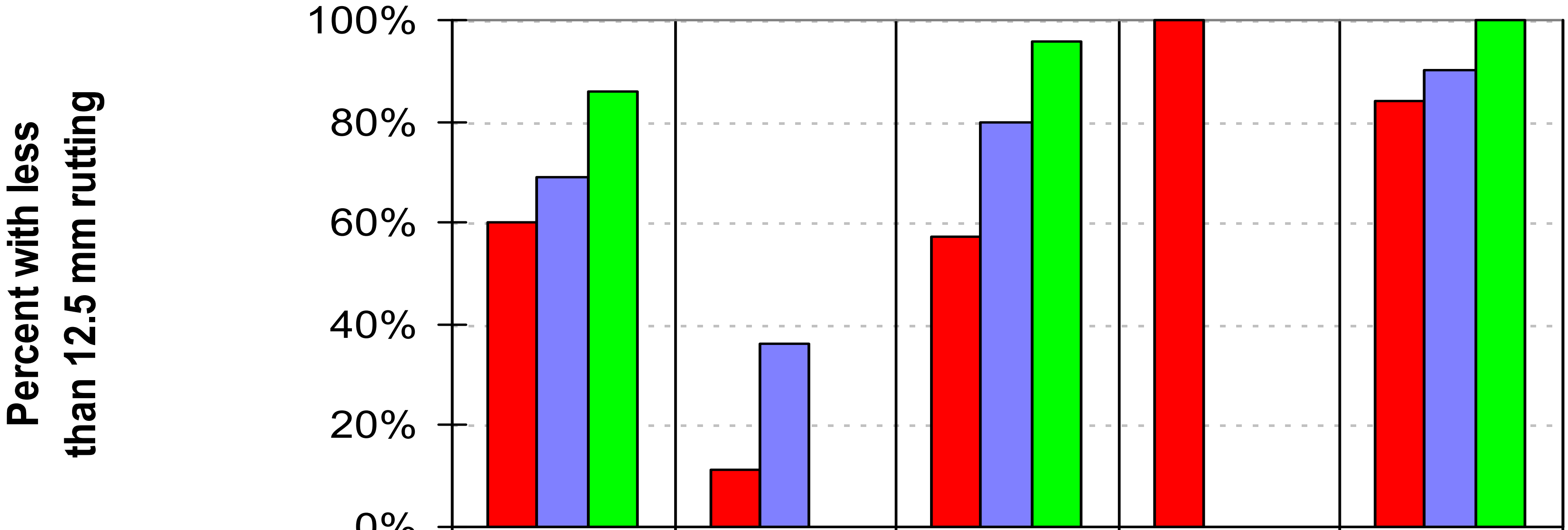
Rutting: 12.5+ mm # of Passes: 13,300* Temp: 50C

District:“Research” Mix Type: CMHB-C Binder: 70-22

Aggr.: Limestone Additive: None ID: 540067

Influence of aggregate type @ 50 °C

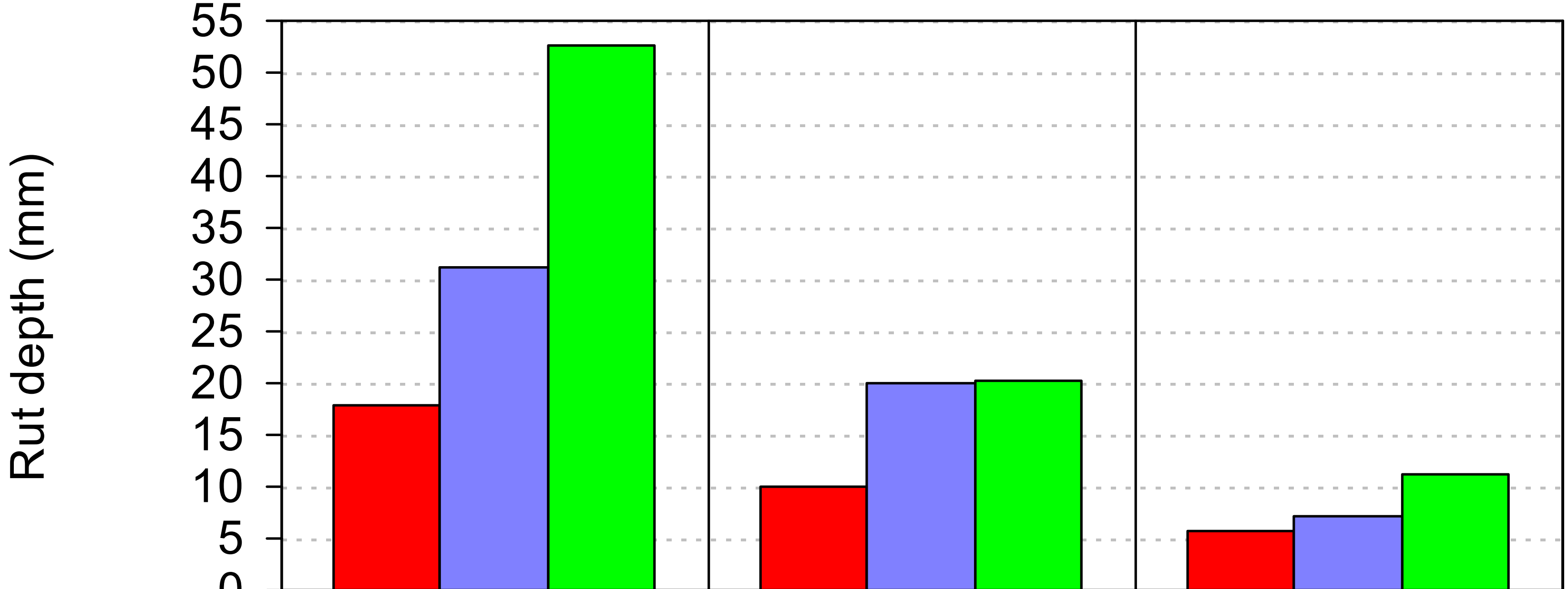
LIME ADDITIVE   Includes all mix types



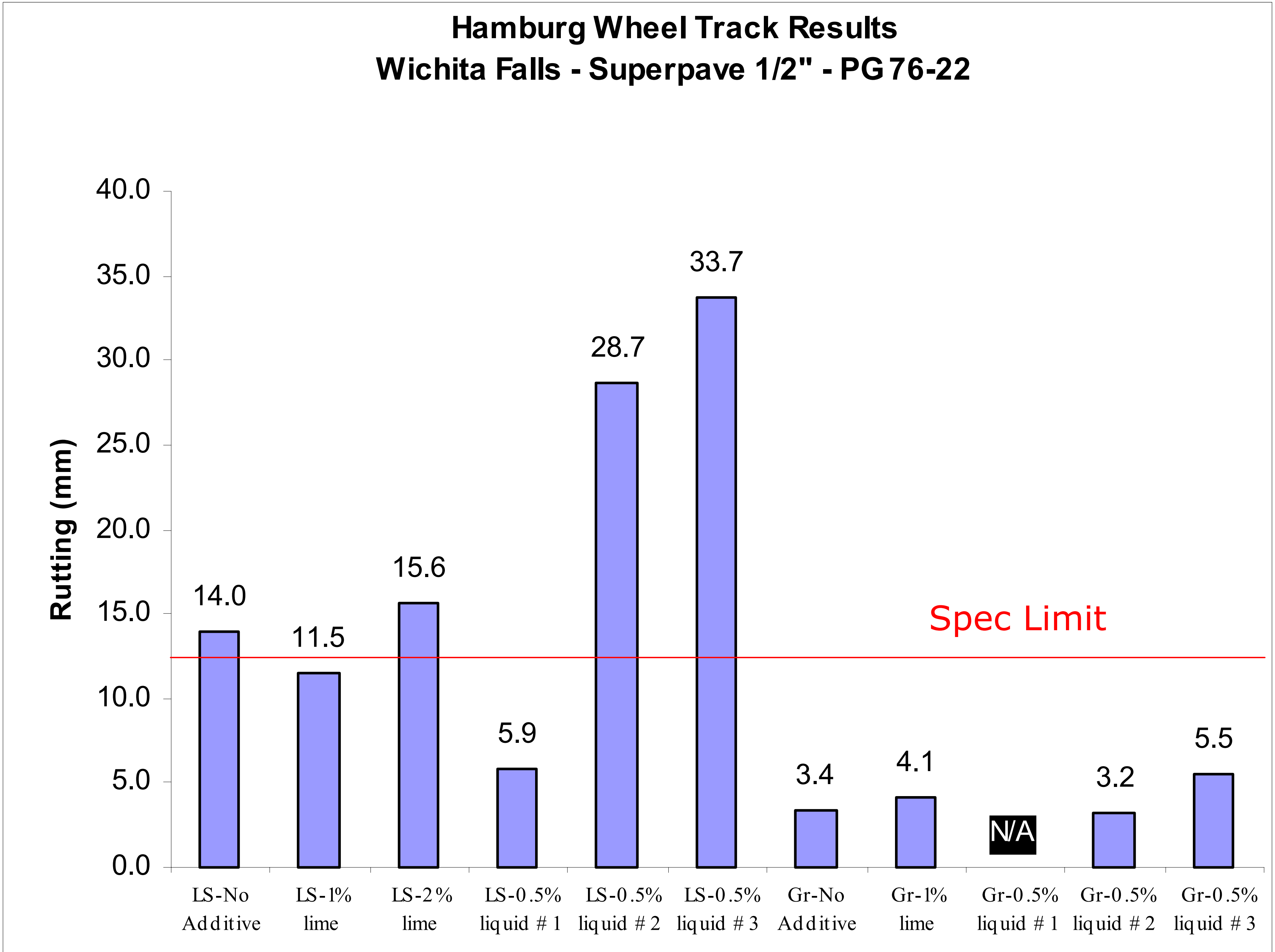
	PG 64-22	PG 64-28	PG 70-22	PG 70-28	PG 76-22
Limestone	60.0%	11.1%	57.1%	100.0%	83.9%
Gravel	69.2%	36.4%	80.0%		90.0%
Igneous	85.7%		95.7%		100.0%
Count (Limestone)	15	9	42	6	56
Count (Igneous)	7		23		33
Count (Gravel)	13	11	20		40

Effect of binder grade and additive type

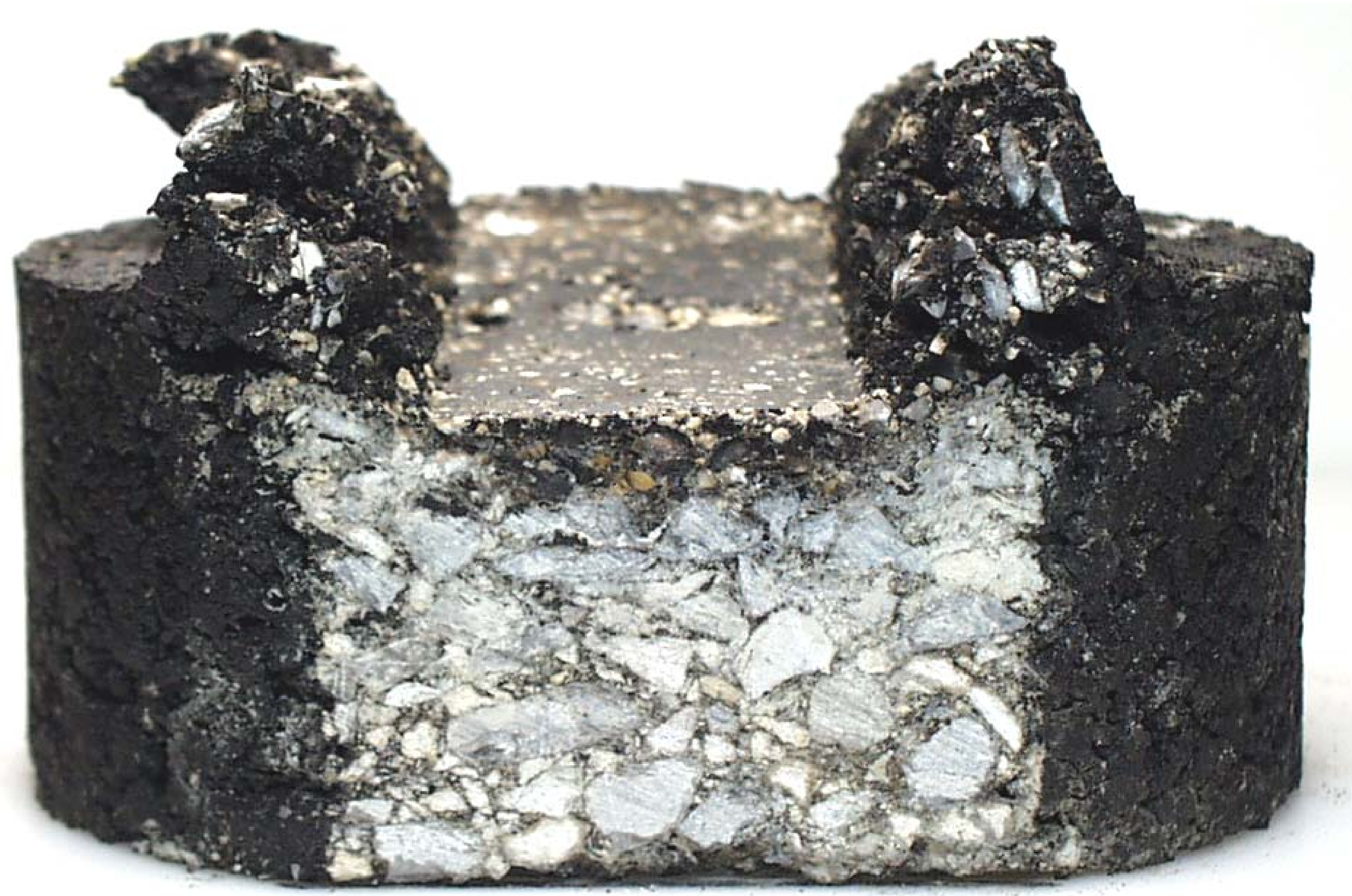
Includes all: 50 °C, mix types & aggregate types



	PG 64-22	PG 70-22	PG 76-22
Lime	18.0	10.0	5.7
Liquid	31.2	20.1	7.2
None	52.6	20.3	11.2
Count (Lime)	41	94	153
Count (Liquid)	38	35	51
Count (None)	29	34	63


Hamburg Wheel Track Results
Wichita Falls - Superpave 1/2" - PG 76-22
Rutting (mm)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
14.0
11.5
15.6
5.9
28.7
33.7
3.4
4.1
N/A
3.2
5.5
Spec Limit
LS-No Additive
LS-1% lime
LS-2% lime
LS-0.5% liquid # 1
LS-0.5% liquid # 2
LS-0.5% liquid # 3
Gr-No Additive
Gr-1% lime
Gr-0.5% liquid # 1
Gr-0.5% liquid # 2
Gr-0.5% liquid # 3

Rutting: 11.5 mm # of Passes: 20,000 Temp: 50C



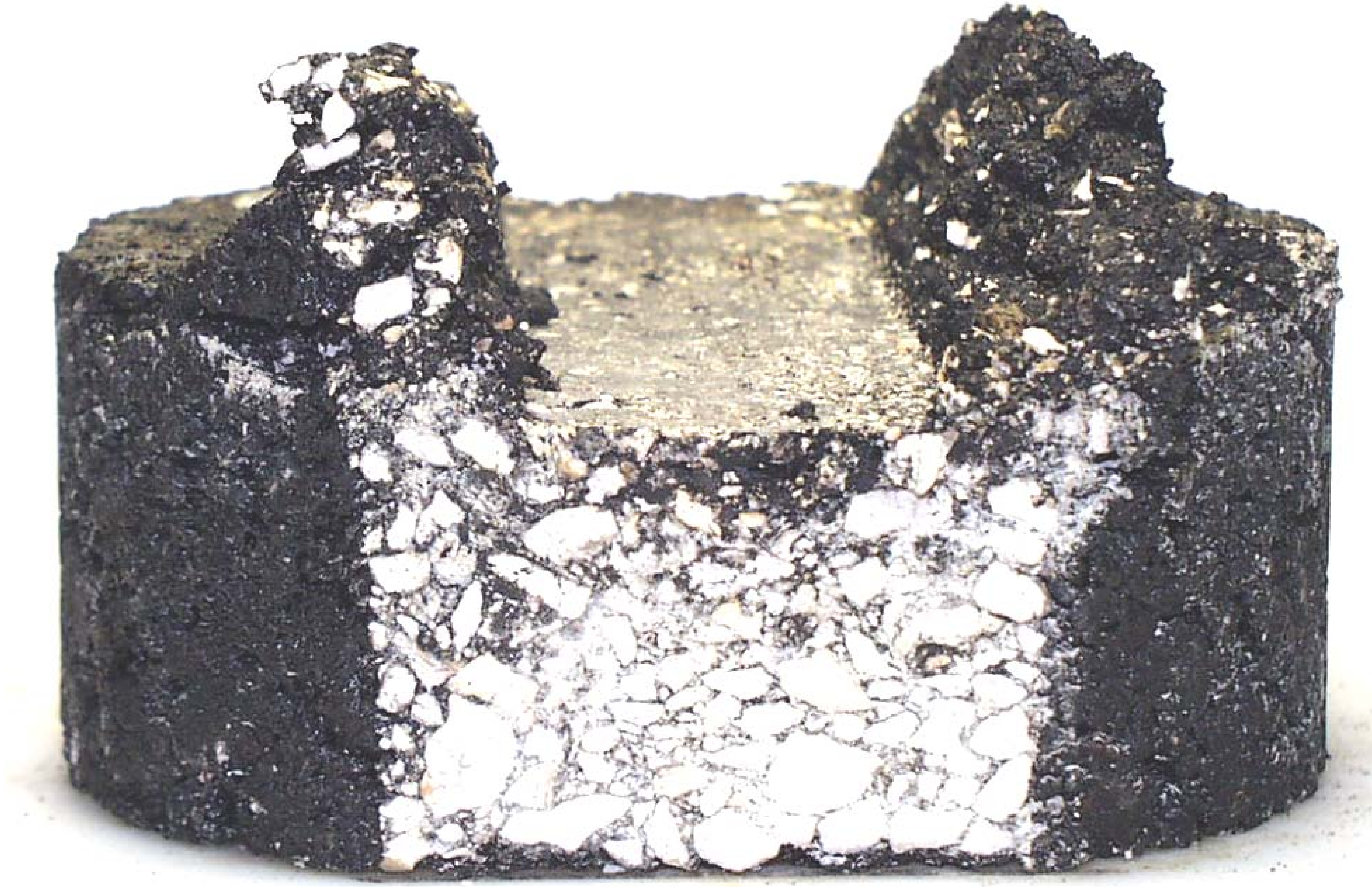
District: Wichita Falls	Mix Type: Superpave (0.5)	Binder: Koch 76-22
CSJ: 0044-01-076	Aggr.: Limestone	Additive: Lime 1.0%
ID: 00540123	Plant Mix	Notes:

Rutting: 2.9 mm # of Passes: 20,000 Temp: 50C

District: W.Falls Mix Type: Superpave (0.5) Binder: 76-22

Aggr.: Granite+ Additive: Lime(1%) ID: 540027

Rutting: 12.5 mm # of Passes: 10,200 Temp: 50C



District: Abilene

Mix Type: Superpave

Binder: **76-22 (Source 1)**

CSJ: 0068-07-046

Aggr.: Limestone

Additive: None

ID: 01500318

Lab Mix

Notes:

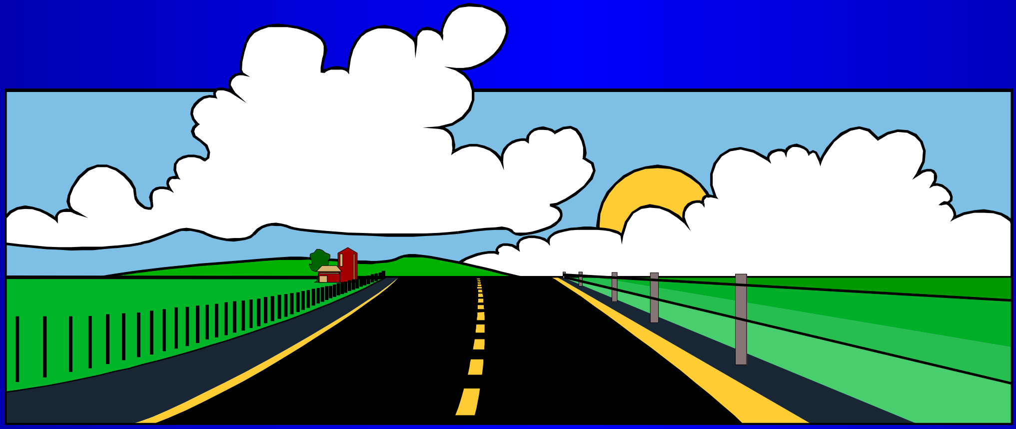
Rutting: 2.8 mm # of Passes: 20,000 Temp: 50C

District: Abilene Mix Type: Superpave Binder: **76-22 (Source 2)**

CSJ: 0068-07-046 Aggr.: Limestone Additive: None

ID: 01500380 Lab Mix Notes:

THANK YOU!



FIELD EXPERIENCE OF ASPHALT CONCRETE MOISTURE DAMAGE IN VIRGINIA

G. W. Maupin, Jr.
Principal Research Scientist

VIRGINIA’S HISTORY

- Began to recognize in late 1960’s
- Failures were often catastrophic
- Started to use additives in early 1970’s
- Instituted use of TSR test for mix design
- Although distresses are not catastrophic a recent survey revealed considerable stripping in cores

TYPICAL PAVEMENT DISTRESSES

30 Years Ago

Today

Virginia Department of Transportation
VDOT

MATERIALS AND ENVIRONMENT

- Aggregates – granites (primary), diabases/traprocks, quartizites, gravels, limestones
- All mixtures must contain an additive
- Rainfall approximately 100 cm/year
- Some freeze-thaw cycling
- Summer temperatures may reach 35 degrees centigrade or slightly higher

DESIGN AND PRODUCTION TESTING

- Participated in Bob Lottman’s work and became familiar with TSR test
- Type of TSR test and criterion have changed slightly over the years
- AASHTO T 283 test now required for design and used some for production
- Although it is has weaknesses it is the best test currently available

Virginia Department of Transportation

RECENT STATEWIDE SURVEY

- 1400 cores examined visually
- 40-50 percent displayed moderate to moderately severe stripping
- Pavement distress mostly limited to cracking
- How much does stripping affect service life?
- Lab study in progress to answer question

Virginia Department of Transportation VDOT

CURRENT LAB STUDY

- Identify some mixtures that strip
- Make lab specimens with various degrees of visual stripping
- Perform lab tests to predict effect on service life
- Use fatigue tests and possibly rut tests

FIELD INVESTIGATIONS

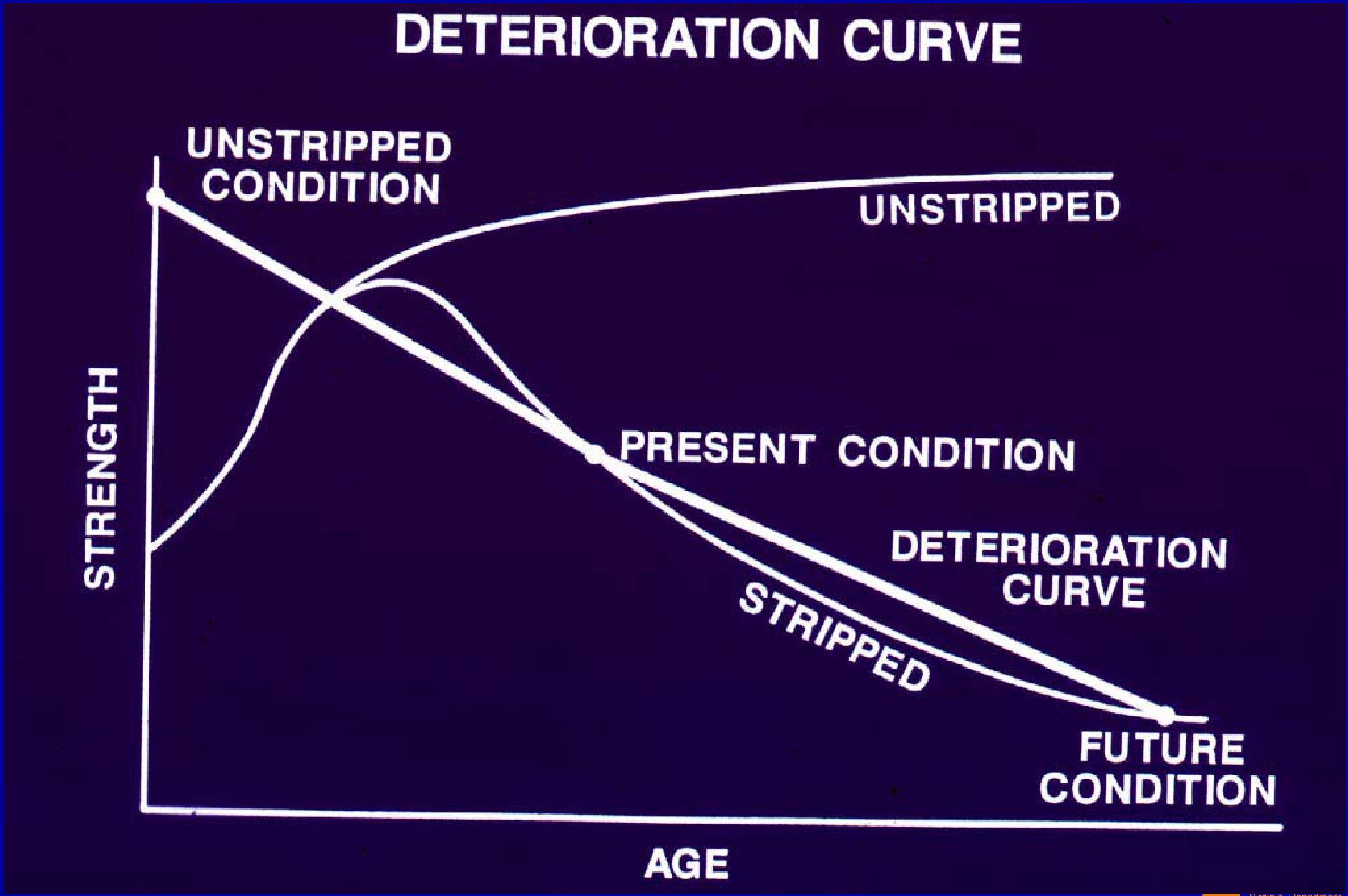
- Use visual and tensile strength methods
- Visual method used most often (simple)
- Visual method not precise or reproducible
- Several ways of examining strength data
- Strength method more labor intensive and time-consuming

Virginia Department of Transportation

CORE STRENGTH

- Use minimum in-place strength criteria
- Use minimum in-place strength ratio criteria
- Use minimum conditioned strength criteria
- Use minimum conditioned strength ratio criteria
- Use some combination of the above

STRENGTH INTERPRETATIONS



SUMMARY

- Require additives
- Performance has improved
- TSR test is used but better test is desirable
- Damage caused by stripping is unknown
- Visual and strength forensic examinations

Comparison

- Widespread – NV (lime), VA (lime, liquid)
- Local – CA (lime, liquid), TX (lime, liquid)

- T283 - poor tie w/ long-term field performance

- CA – HWTD ?
- NV – M_R forensic
- TX – HWTD
- VA – remaining life

Recommendations

- Improve Laboratory Test & Criteria
- Test Each Combination of Materials
- Couple w/ Other Measures
- Understand Mechanism
- Continue Sharing Experience